MODERNIZING THE U.S. ARMY CORPS OF ENGINEERS WATER CONTROL DATA SYSTEM

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Abstract: The Water Control Data System (WCDS) is the data acquisition, management, modeling and decision support system that supports the Corps water control mission of regulating more than 500 dam and reservoir projects. The WCDS is a nationwide integrated system of hardware and software that allows user access to virtually any data and information in the system. The base system was operational in the 1988-1990 time frame. Advances in computer and related hardware and software provide the opportunity to upgrade WCDS and improve execution of the water control mission. The Corps is modernizing WCDS by replacing computer hardware, upgrading data acquisition hardware and software, creating a corporate water control database system, and upgrading and developing new modeling and decision support software. This paper describes the existing WCDS system, modernization activities, and current status.

INTRODUCTION

The WCDS is the automated information system (AIS) that supports the Corps of Engineers water control mission including the hardware, software, man-power and other resources required to acquire, develop, maintain, operate, and manage the system. The WCDS includes the collection, acquisition, retrieval, verification, storage, display, transmission, dissemination, interpretation and archival of data and information needed to carry out the water control mission of the Corps. Typically this data and information includes hydrologic, meteorologic, water quality, and project data and information. The system collects data on a near continuous basis from thousands of automated sensors throughout the nation. In addition, the system acquires spatial satellite and radar imagery, graphical products, text products, lab and field analyses of chemical, physical and biological samples. The system through it's software incorporates this data and information into various user products and system outputs. The WCDS is a nationwide integrated system of hardware and software that allow user access to virtually any data and information in the system. A suite of software gives users the ability to display, manipulate, disseminate, interpret, and transmit this information throughout the Corps and to numerous other interested users.

The system supports the information needs for Corps water control decisions. There are hundreds of water control decisions made each day during normal hydrometeorological conditions. These include decisions of reservoir releases, power generation, navigation structure operation, facilities maintenance scheduling, special event operations - the list is quite long. The number and difficulty of these decisions, and consequently the information support needs, vastly increases during flood and other extreme events. Most day-to-day water control decisions are made at the staff level in district offices, with oversight and support at division level. In some situations, real-time decisions for main-stem projects that require a broad regional perspective are made at the division level.

Other Corps functions served by information from the WCDS include flood fight and emergency management; environmental, land, and recreation system management; and the myriad of water-related interests of the Corps. Information is shared with other federal and local agencies to enable efficient, coordinated accomplishment of complementary activities. Local partners, users, and the general public are also consumers of the information provided by the WCDS.

EXISTING WCDS

The WCDS is an existing system, characterized as fully operational in the circa 1988-1990 time frame. The system evolved over the period 1975 to 1990. The system was then comprised of dedicated Harris mini-computers, data acquisition and communications hardware, and Corps-wide developed and fielded software, and locally developed software. Although guided by Corps-wide policy, the circa 1988-1990 WCDS was not a centrally planned and developed system except for the computer hardware. The Harris mini-computers, 24 total, were acquired via a centrally managed activity. A few offices used other computer equipment. The accumulated investment in the existing circa 1988-1990 system is estimated at $80 million.

Software was developed to address various aspects of the basic WCDS functions. A portion of the software was developed for Corps-wide usage but substantial development took place in local district and division water control offices. The Corps-wide software was developed by the Corps Hydrologic Engineering Center (HEC) as reimbursable products for field offices. The software was subsequently generalized for Corps-wide application. A total of 54 HEC developed programs comprised of about 600,000 lines of code (mostly Fortran with some C) formed the Corps-wide WCDS software. Only a few Corps offices implemented the full suite of software but most offices make use of the HEC-DSS data storage system as the central data manager.

MODERNIZATION NEEDS AND OPPORTUNITIES

The circa 1988-1990 WCDS computer equipment was aged and data acquisition and processing requirements increased beyond capacity; operation and maintenance was costly; and staff requirements to continue useful service excessive. The water control decision process continues to increase in complexity and involve more interested parties. This in turn increases the need for improved responsiveness in information acquisition, processing, display, and communications/exchange. Recent extreme events, such as the Mississippi flood of 1993, taxed the limits of WCDS and exposed the need for improved capabilities. At the same time, substantial advances in network communications, computer and related hardware, and companion modern software, provide the opportunity to substantially improve execution of the water control mission. System modernization is planned to address both cost reduction and performance improvements.

Corps Corporate Perspective: Viewed from a corporate perspective, the existing WCDS was a patchwork of individual systems. The systems are largely locally maintained, managed and supported. Each system is a blend of user developed software, Corps developed and supported

software, and commercial software. This independent development has produced great disparity in the level of performance and capability across the Corps. The existing systems can support needs given ample fiscal and manpower resources. However, many of the existing systems are inadequate to effectively move data and information through the Corps organization and to our customers. Data acquisition, data management, communication, display, and report generation are generally cumbersome and labor intensive efforts. Modeling and forecasting are usually performed only on the most highly developed systems and even there these tools are often intermittently applied. The uniqueness of locally developed software to accomplish similar tasks at many districts frustrates effective technology transfer. Modernization is necessary to provide the tools needed in a reliable networked system of hardware and software that can be locally configured to meet the unique requirements of each user.

New Network and Workstation Technology: Workstations have processing capability orders of magnitude greater than the Harris mini-computers at a fraction of the cost. Likewise, communications and network hardware and software technologies have rapidly advanced. Network technology is common place within Corps offices and other cooperating federal and local government agencies. Integrated with appropriate software, network technology increases access to data sources, improves processing power for flow forecasting, impact analysis, and decision support modeling, and increases effectiveness in exchange of information.

New Data Sources: Important new data sources for input to real-time regulation decisions are now available. Geographic Information Systems (GIS) are commonly employed by the Corps and other state and local agencies to manage land-based information. Satellite imagery, and other spacecraft remote sensing data, are now routinely downloaded and displayed for scientific as well as general public information. Analysis methods to make use of such data continues to be developed in Federal government research laboratories, universities, and the private sector. Integrated with ground-based radar sensor data, in-situ measurements, and data handling and processing systems, these capabilities offer important advances in information support to the Corps real-time water control mission.

Improved Data Management Technology: Software for storing, retrieving, manipulating, and displaying a wide range of data has improved markedly over that of the last decade. The opportunity exists to develop a corporate Corps-wide water control data base system that would serve real-time as well as other water management information needs. Integration of data, models, and information management via the corporate data base would provide an order of magnitude improvement in overall data handling within the WCDS.

New Modeling, Forecasting, and Decision Support Tools: Advances in software that will take advantage of new and improved data sources and analytical analysis methods, implemented within state-of-the-art computer processing and network systems, would provide the critical element in improved information for water control decisions. Software to incorporate spatial precipitation data available from NEXRAD for forecasting, optimization algorithms for reservoir regulation, economic/flood damage impacts, and environmental effects are examples of advanced software tools that hold promise of significant contributions.

WCDS MODERNIZATION PROJECT

The WCDS modernization project includes replacement of pre-1990 computer and related hardware; upgrades to field instrumentation and communications equipment; and upgrading existing WCDS software including porting exiting products, modifying and upgrading existing products, development of new software products, and acquisition and adaptation of Commercial Off-The-Shelf (COTS) software. Incorporated within the project are both centrally developed and maintained software and field developed software. Modernizing WCDS will standardize equipment, data handling, and software and thus ensure maintainability, upgradability, and usability. The project integrates activities among headquarters, field offices, and supporting offices.

The broad outlines of the modernized WCDS are documented in (USACE, 1995). On the hardware side, replacement of the Harris mini-computers began in the early 1990's and by 1996, all had been replaced by UNIX workstations. Technology insertion options in procurement contracts provide that as new workstations are acquired, state-of-the-art workstations are delivered. The Corps corporate communications system provides the basic network infrastructure that meets the modernized system connectivity requirements. The tasks requiring focused attention include software upgrades and additions, and hardware/software systems integration. The specific software requirements of the modernized system are documented in a series of 'Requirements Specifications' (USACE, 1997) that are guiding the system development. Figure 1 is a schematic for a prototype of the initial version of the modernized system. The prototype will be a limited capability but fully functional WCDS. The prototype diagram illustrates functional integration of the WCDS components. The meaning of abbreviations and acronyms in Figure 1 are defined in the sections that follow.

Data Acquisition: The data acquisition module will receive the suite of National Weather Service (NWS) products including text, graphics SHEF and digital products (including NEXRAD stage III data); GOES/DOMSAT text products, land-based radio, cooperating agency data, manual entry data, and direct (PUPIE) radar data. Processing capability will include decoding and transforming data received into usable forms and units via math functions; data verification; producing graphic products and reports; and delivering data acquisition products to the data base. Prototype data acquisition functions are depicted in the DA circle in Figure 1.

Data Base: The data base module will be comprised of an Oracle relational data base system and supporting temporary data cache and working files. Data to be stored includes: non-recurrent data such as documents, project data, imagery, text, notification lists, messages, WCDS component operational status, and gage status; recurrent data such as gage and radar products, NWS products and remote sensed data; and recurrent derived data such as model simulation results, transformed data, and software execution logs. Data objects for application usage include time series, spatial, hydraulics, documents, watershed, reservoir, GIS, economic impact, WWW interface, and gage accounting. Utility support includes a full suite of queries, import/export conversion and formats, and archiving. Data base management and performance tuning and data base security and access

control will be provided. The data base function/module is depicted in Figure 1 by the DB circle.

Data Dissemination: Types of data to be disseminated include time series, paired , spatial, text, image, schematic, and multimedia. Delivery methods include World Wide Web technology (WWW), FTP, E-mail, fax, pager, and, recorded messages. Dissemination will occur locally within a Corps district office, among other district/division offices, Corps headquarters, cooperating agencies, and the general public. The data source will be the Oracle data base. Data recipients can retrieve and mathematically manipulate data, manipulate graphics, and generate tabular, graphic and text products.
 Specific report products will be developed for data acquisition and dissemination,